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adopting antimalarial measures. Already there are two places in North Carolina, one, Knotts Island, under the direction of the State board of health, and another, Roanoke Rapids, under the direction of Dr. T. W. M. Long, undertaking such work, which places will undoubtedly serve as a demonstration that the disease is preventable and can be controlled, if not eliminated, when a community desires to carry out intelligent prophylactic measures based on the principle that the Anopheles mosquito is the only transmitting agent of malaria from man to man.

Letters have been sent to State health officers of Alabama, Arkansas, Florida, Georgia, Mississippi, North Carolina, South Carolina, and Tennessee, requesting them to select localities in their respective States in which they desire surveys to be made. It was stated that on the part of the United States Public Health Service surveys of localities will be undertaken to ascertain—

1. Malarial index.
2. Breeding places of Anopheles.
3. Species of Anopheles present.
4. The most practicable measures to be immediately adopted for control.
5. Educational work, by means of lectures, lantern-slide demonstrations, etc.

Acknowledgments are due to the State health officers who cooperated in furnishing statistics, in having postal cards addressed, in the collection of data and material, and in many other ways; also to all physicians who replied to the circular postal cards, and to those who furnished and assisted in the collection of materials.

THE POLLUTION OF TIDAL WATERS.

ITS BEARING ON HEALTH AND THE IMPORTANCE TO THE STATE OF ITS CONTROL.[1]

By HUGH S. CUMMING, Surgeon, United States Public Health Service.

It seems peculiarly appropriate that a subject involving the welfare of the tidal waters of Maryland should be discussed here where for years labored Prof. Brooks, who probably more than any other brought their actual and potential economic value to the attention of her citizens.

I have been honored by the request to discuss the subject, "The bearing of pollution of tidal waters on health and the importance to the State of the control of such pollution."

Not many years have passed since communities, as a matter of course, discharged their pollution untreated into the nearest stream without thought of consequences other than such gross pollution as would offend the eye and nose of their own residents. Many American cities continue to do this. Later, when modern science directed attention to the evil consequences of such action upon the health of cities lower down such streams, communities counted themselves fortunate when they could with apparent impunity discharge their sewage into mother ocean or one of her branches as carelessly as a housewife empties her laundry water on the ground.

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[1] Read before the Maryland Conservation Association at its first annual meeting, Baltimore, Md., Feb. 25, 1914.

Even later, when the rapid growth of our American cities and the increase of sewerage systems created intolerable conditions, such as formerly existed in the basin of Baltimore Harbor, the measures for prevention were directed rather toward abating disgusting flotsam and putrefactive gases and odors than toward the protection of the public health.

As a nation we Americans have from the earliest time until recently been prodigal in our waste of resources, our minerals, our food supply, and, most important of all, our health.

This is a time of awakening. We are realizing the value of health and lives even from a monetary standpoint, and this sanitary awakening is due to the advances of science and to the able work of such men as Dr. Welch and Dr. Fulton, of your State, in applying this knowledge to the health of the State.

The Extent and Nature of Pollution of Streams.

What is meant by pollution? It is the result of the introduction of sewage, which is the waste from houses, streets, and factories. Average sewage contains 999 parts of water to 1 part of solids. About one-half of this one part consists of mineral matters and one-half of organic matters capable of decomposition.

About three-fourths of the mineral matters are in a dissolved state. Of the organic matter, with which we are most interested from a sanitary point, about one-half, or about 200 parts per million of total sewage, is in solution, the other half in suspension. Basing our estimate either on the average reported by Fuller for 10 cities or on the analyses of Phelps and Winslow, which indicate that these impurities are equivalent to from 42.3 to 46 tons of dry solid material per year per 1,000 inhabitants, we may realize the quantity of pollution from communities of any size.

Danger of Pollution.

Not all of this pollution is directly dangerous, but sewage includes in addition to billions of other intestinal organisms those of typhoid fever and other water-borne diseases. Many persons for years after they have recovered continue to discharge the organism causing typhoid fever while others who apparently have never been ill carry and distribute these germs for years.

Such pollution is called infectious pollution, and all sewers are either constantly discharging such pollution or there is the danger of their so doing.

Changes in Sewage After Entering Stream—"Self Purification."

The important question arises as to what becomes of these solid and liquid organic constituents of sewage.

If sewage be discharged unscreened or untreated into a stream, its surface will hold large and small masses of feces, grease, paper, and other things lighter than water or buoyed by gases. The water varies from the turbid, greasy, slate color of fresh sewage to the almost black, foul smelling, bubbling waters of stale sewage.

The future changes in sewage will now depend upon the amount of free or dissolved oxygen in the stream, for the sewage will already have exhausted nearly all of the free oxygen contained in its waters.

Whatever the intermediate steps may be, the ultimate disposition of the organic compounds is a breaking up into stable, inoffensive forms by means of oxidation. These processes are really a slow combustion. If there be sufficient oxygen present in contact with the organic matter, some will be directly oxidized, the action of the bacterial life usually present will further oxidize another portion, and the process will proceed without foul odors.

In the absence of sufficient oxygen the action of the putrefactive organisms will result in producing offensive, unstable compounds which must be finally oxidized.

The final products of all these processes are water, carbon dioxide, and ammonia, which further oxidizes to nitrous and nitric acid, these acids finally uniting with alkalies to form nitrites and nitrates. During this process of oxidation many of the dangerous intestinal organisms are being destroyed, for they are not in their natural environment, but others more resistant continue to live for a time dependent upon local conditions of oxidation, temperature, and possibly antagonistic normal bacterial and animal forms in the water.

The Essential Factors in the Self Purification of Polluted Waters.

The two essential factors in the self purification of polluted waters are oxygen and time. So far, therefore, as nuisance from appearance and odors is concerned, communities may freely discharge sewage into a stream if it, first, be treated to prevent floating or accumulating masses; second, if the current be enough to carry it away; and, third, if the proportions of water to sewage be such as to furnish abundant dissolved oxygen. A proportion of 1 of sewage to 50 of stream water is sufficient, but the dissolved oxygen content is the best index. Unfortunately, disease germs may at times. survive until they reach the water intake of another city or shellfish layings.

Conditions Affecting Purification of Polluted Tidal Waters.

Now, in tidal waters there are quite different conditions. While in an encyclopædic sense "tidal waters" include all bodies of water affected by tides, for instance, such portions of rivers as are found at the intakes of Philadelphia and Wilmington, for our discussion we shall consider waters where land and sea waters meet as tidal waters. Conditions in such waters are unfavorable for sewage disposal because—

First. In place of a constant river current we have a slow, oscillating swing of the tides four times daily with four periods of quiescence at slack water.

The currents are variable, more rapid on top in the channel, less rapid at the bottom and sides. As the capacity of water to move solids varies with the sixth power of the velocity, we can realize what a degree of sedimentation must occur during the periods of quiescence.

While the river currents cause some net seaward movement, so little is gained in the 3-mile swing of each tide in Chesapeake Bay that according to the United States Coast and Geodetic Survey it takes 138.4 days on the average for a floating particle, or 103.8 days for one following the channel, to travel from Pooles Island to Point Lookout.

Second. The transporting power of a river for solids in suspension is decreased by the presence of sea water; therefore, sewage discharged into tidal waters will deposit more solids than would be deposited in land water; consequently more putrefactive changes take place in the bottom mud. Roughly speaking, sea water deposits its suspended matter 10 or 12 times more rapidly than land water.

Third. Sea water contains much less available dissolved oxygen than unpolluted land water and reaeration is less rapid.

Fourth. The odors resulting from putrefactive changes following sedimentation and the lack of oxygen are more offensive than in land waters.

Finally, available evidence goes to show that typhoid germs will live for a considerable length of time in sea water or brackish water.

Summarizing, then, we find in tidal waters (*a*) comparatively concentrated areas of pollution, (*b*) decreased destruction by oxidation, (*c*) increased nuisance from putrefaction in consequence, and (*d*) not much difference in viability of disease germs.

The important factor of degree of dilution varies, of course, with each community.

Pollution by Industrial Wastes.

In addition to these ordinary wastes from our cities, streams and tributaries are frequently polluted by the wastes of our great industries.

Although this pollution, as a rule, is of less sanitary significance, it is often a serious factor in the general problem because of its large volume and concentrated nature.

Moreover, its treatment and disposal often present unusual difficulties which are further aggravated by the fact that the costs must be borne by the manufacturers themselves, who derive little or no benefit from such treatment.

This is an aspect of the question which has long attracted the attention of our more progressive State authorities, but which, nevertheless, remains one of our great problems for future solution.

Bearing of Sewage Pollution upon Health.

Now, let us discuss the bearing of sewage pollution upon health.

As Fuller expresses it—

> There are two principal nuisances which are conspicuously due to sewage. The first is caused by conditions that are offensive to the sight and smell. The second class of nuisance is associated with the disease germs contained in sewage and which are transmitted to neighboring communities through the water of the stream into which the sewage is discharged or through shellfish.

The first type of nuisance may be dismissed in a few words, for it would be an insult to the intelligence and sense of decency of this Association to waste time in showing that no community should allow masses of garbage, offal, human dejecta, or other solid matter, recognizable as of sewage origin, to float in its harbor, disfigure its shores, or poison its atmosphere. Aside from the danger of disease thus produced, there is another objection, and Dr. Gilbert Fowler, of Manchester, England, has well expressed it as follows:

> But even more important than the direct and obvious ways in which the public health is affected by the polluted conditions of the harbor waters is the practically unconscious lowering of that sense of decency and cleanliness of living which must be maintained if the efforts of social reformers are to have any serious results.

Effect of the Pollution of Tidal Waters on Food Fish.

The economic question of the destruction of food fish or preventing them from going through the polluted waters to their spawning grounds up the rivers is important. The reduction of the dissolved oxygen below a certain standard by the presence of sewage or the deleterious action of a large amount of industrial wastes will render waters uninhabitable for fish.

The standards should be such that there is a minimum of disagreeable odors and appearance and that pollution is not too great for fish life.

The best index of this is the amount of dissolved oxygen present. A minimum of 50 to 70 per cent is a fair one.

Danger of Bathing in Polluted Waters.

The question of bathing in and near large communities is important. One of the greatest sources of pleasure and health to the residents in our tidewater cities is bathing on the water front or beaches in or near the cities. A great deal of wealth is brought to coast States by inland people who come to the shore resorts. Few persons bathe without getting some water into their mouths; consequently, bathing should be allowed only where the water is approximately as good as drinking water. Typhoid fever has undoubtedly been contracted in this way.

It is not practicable to maintain such a standard on the water front of our large communities, but it is practicable to protect near-by shores.

So far we have discussed the question in its local effect upon the health of the people. The pollution of tidal waters, however, has now assumed not merely State but National sanitary importance.

National Importance of the Pollution of Tidal Waters—Relation to Shellfish Industry.

From the time when our forefathers first landed on these shores and found oysters in our waters as abundant as were the buffalo on the plains and the wood pigeons in the forests, these delicious, nutritious shellfish have formed one of our most important foods and have furnished a livelihood to thousands of our citizens from Cape Cod to Biloxi.

Transported inland only by wagon in the earliest days the market for them has been extended by improved transportation facilities and refrigeration until now they may be eaten in the restaurants of Denver and are being carried alive and transplanted into the harbors of the Pacific coast.

In 1837 the first raw packing house was established in Baltimore. Connecticut, Rhode Island, New York, New Jersey, Maryland, and Virginia have always led in this great industry. Although Virginia as early as 1810 passed laws regulating the oyster trade and, owing in part to her present laws, now leads in this industry, as a whole our people, with characteristic American optimism and extravagance, have spent both their capital and legitimate income from this great bank of nature until Maryland, for example, has fallen in her production from 15,000,000 bushels of oysters in 1888 to about 3,500,000 in 1912.

In recent years, however, we have at last begun to take stock of all our resources and attempt to conserve them. I doubt not that very soon good laws and, more important, an intelligent public opinion will ultimately result in our shellfish becoming the great food supply and the great source of wealth so elequently described by Brooks.

Where Oysters Grow.

The oyster grows in tidal waters where the rivers bring down mineral and organic wealth and where are found the minute organisms which serve the oyster as food. This is the region where land and sea water meet and where, as we have seen, sedimentation of suspended solids, including sewage if it be present, is greatest.

The oysters obtain their food by sucking in large quantities of water, from which is strained, in their gill, everything in suspension. Each oyster thus probably passes through itself 10 or 12 gallons of water daily, and Prof. Brooks believed it probable that all the waters of the Susquehanna go through oysters before reaching the ocean. If disease organisms be present they, too, are drawn into the oyster; and while it is probably true that many are digested in its stomach, many are detained in the liquor and remain uninjured in the gills, so that in bacterial study we find many more organisms in the liquor than in the same amount of the water surrounding the oyster. Investigation has shown that not only do disease germs remain alive in the oyster shell after the oyster is removed from the water, but, at least in some cases, they rapidly multiply.

So long as the taking of oysters was a local affair and communities were small, the purchaser could know the situation and sanitary condition of the bed whence came his oysters, but with the increase of the polluted area, means for transportation, and widening of the market comes loss of identity. Once shipped, the oyster bears no mark by which the consumer can tell the presence or absence of infectious pollution; he must depend upon the shipper or the law for protection.

Now, the people of the country have been more or less aroused to the modes of conveyance of disease, especially typhoid fever. There has been a great deal written about oysters conveying disease, and already sentiment has abolished this food from many households.

Undoubtedly many cases of illness have been incorrectly attributed to shellfish infection, undoubtedly many oysters from safe layings have been infected in handling, and undoubtedly many articles written and reports made have been radical, superficial, and have seriously and unjustly injured a great food product; but it is equally true that cases of illness and deaths have been and are being caused by eating oysters from infected beds or from polluted waters, in which they are placed to increase their bulk, and the danger is increasing with the increased amount of sewage in tidal waters near growing communities.

The condition is somewhat analogous to the milk industry. Many dealers would without legal compulsion sell pure milk, many through ignorance furnish dangerous milk, and a few will not scruple to sell anything for money.

A very large proportion of oysters are a perfectly safe food when bought by the consumer; a larger number are free from infection when taken from their layings. Many planters use intelligence in caring for oysters; some even employ bacteriologists so they may know the sanitary condition of their beds. But there remains a certain proportion of oysters which are taken from polluted beds and others which are plumped in polluted waters. These are dangerous to the lives and health of persons who use them.

We have learned or shall learn that we can not, as a Nation or State, now depend upon nature unaided for our food supply, whether it be vegetable, meat, oysters, or fish. Conditions in civilized countries are such that we must encourage and cultivate all of these sources of food if the supply is to be equal to the demand.

As the result of intelligent legislation in some States, thousands of dollars are being or have already been invested in increasing the supply of shellfish.

This great industry, already so important to the thousands of our people who catch and sell oysters, is of equal importance to the hundreds of thousands of citizens of other States, who should look upon them as a cheap, healthful, delicious food. The safeguarding of the industry itself and, what is more important, of the health of the people, demands the best thought and action of State and Federal Governments. On the one hand, the people throughout the whole country should know, when they buy shellfish, that they do not come from polluted beds, have been carefully handled, and that the municipal, State, and Federal Governments have at least exercised the supervision and care that are given to meat and other foods. On the other hand, our planters are entitled to know before they invest large sums of money just which layings are considered safe and which unsafe.

Regulation of Pollution of Tidal Waters.

Much can be done by municipalities regulating the handling of shellfish and a great deal by the States in regulating pollution and use of polluted waters.

Your own city of Baltimore has expended a vast sum to protect the layings of the upper bay, and New Jersey has a law forbidding sewage pollution, as a result of which about 150 of her communities have sewage-disposal plants which protect water supplies, bathing beaches, and shellfish layings.

Good judgment should be used in supervision. For instance, it would not be justifiable to make a large community expend vast sums to protect beds the actual and potential value of which is small.

On the other hand, valuable beds should be protected from pollution, even if State aid is required by small communities.

Such action would be as proper as State aid for good roads.

The question of allowing oysters to be grown in polluted waters and then transplanted into pure waters is an important one. It is true that oysters will eventually purify themselves, but such a transfer requires careful legal supervision, for it is fraught with dangerous possibilities.

The matter is often beyond State control. Only recently health authorities of a State reported to the Public Health Service an interstate traffic in oysters from beds polluted within the State which it was powerless to prevent.

The Federal Government controls interstate commerce and navigable waters, and the industry is one of national importance in the control of infectious disease.

By an act of Congress the Public Health Service was authorized to study the diseases of man and conditions influencing their propagation and spread, including sanitation and sewage and the pollution, direct or indirect, of the navigable waters of the United States. Under this act the Public Health Service is now planning a systematic study of the more important industrial wastes, of their effect upon navigable waters, and of remedial measures.

Under this same act the service has been, since last June, studying, as a type, the pollution of the Potomac River with reference to the danger from infectious disease, and this investigation will cover a cycle of one year. The Hygienic Laboratory of the Public Health Service has recently been making the bacteriological analyses of samples of oysters being collected by the Bureau of Chemistry of the Department of Agriculture.

There is now being outfitted the Public Health Service steamer *W. D. Bratton.* She is being equipped with a complete field laboratory. Sanitary bacteriologists, chemists, and, when necessary, sanitary engineers will be detailed on board. We shall extend our work to make a sanitary survey of all the tidal waters of Maryland and Virginia in which oysters grow, so that it will be known just which beds are safe, which are dangerous, actually or potentially, and suggestions will be made, when needed, as to means for remedying dangerous conditions.

The present state of uncertainty as to the safety of shellfish throughout the country is unjust both to the producer and to thousands of consumers, who are depriving themselves of one of the most delicious, cheapest, and easily digested foods nature has given us.

It is no idle dream to predict that with intelligent supervision—municipal, State, and Federal—of the pollution of tidal waters, with good State laws and intelligent public sentiment to encourage oyster growing, these great marine farms, fertilized as they are by rivers and the ocean itself, will produce crops which will rival the products of our mines and fields and pour millions of dollars into your coffers, while sanitary supervision of pollution will preserve our harbors for healthful pleasure and profit and prevent much sickness and death.

It is to the intelligent, hearty cooperative labors of such organizations as the Maryland Conservation Association that we look for such an aroused sanitary conscience as will protect our tidal waters from dangerous pollution and its consequences.